



Patent Application
Attorney Docket No.: 57983.000018
Client Reference No.: 12946ROUS01U

At 1/4
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re Application of: :
: Abel C. Dasylva et al. : Group Art Unit: 2633
: :
Appln. No.: 09/749,946 :
: Examiner: Agustin Bello
Filed: December 29, 2000 :
: :
For: TECHNIQUE FOR INTERCHANGING :
WAVELENGTHS IN A MULTI- :
WAVELENGTH SYSTEM :

Mail Stop Appeal Brief-Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL

Sir:

Submitted herewith is an Appeal Brief the above-identified patent application.

[] No additional fee is required.

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	PRESENT # OF CLAIMS	HIGHEST # PREVIOUSLY PAID FOR	EXTRA CLAIMS	RATE	FEE
Total Claims	16	20		x \$50 =	\$.00
Independent Claims	2	3		x \$200 =	\$.00
Multiple Dependent Claims Fee					\$.00
Subtotal					\$.00
Appeal Brief					\$500.00
Subtract ½ if Small Entity					\$.00
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Respectfully submitted,

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APPEAL BRIEF

Sir:

This Appeal Brief is submitted in support of the Notice of
Appeal filed January 21, 2005.

REAL PARTY IN INTEREST

The Appellants, Abel C. Dasylva, Delfin Y. Montuno, and
Guo-Qiang Wang, are the Applicants in the above-identified
patent application. The Appellants have assigned their entire
interest in the above-identified patent application to Nortel
Networks Limited, 2351 Boulevard Alfred-Nobel, St. Laurent,
Quebec H4S 2A9.

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RELATED APPEALS AND INTERFERENCES

The Appellants, the Appellants' legal representative, and the Assignee are not aware of any other appeals or interferences which will directly affect, be directly affected by, or have a bearing on the Board's decision in this Appeal.

STATUS OF CLAIMS

Claims 1-16 are pending in the above-identified patent application. Claims 1-5 and 9-13 were finally rejected in an Office Action dated July 22, 2004. Claims 6-8 and 14-16 were finally objected to in the Office Action dated July 22, 2004. The final rejection of claims 1-5 and 9-13 is hereby appealed.

STATUS OF AMENDMENTS

No claim amendments have been filed subsequent to the Final Office Action dated July 22, 2004.

SUMMARY OF CLAIMED INVENTION

The claimed invention, as set forth in claim 1, and as described and shown in the specification and Figures 1-28 of the above-identified patent application, respectively, is directed to a method for interchanging wavelengths in a multi-wavelength system having W wavelength channels (e.g., see Figures 12, 13,

20 and 24; page 34, line 20, through page 49, line 3). The method may comprise selectively directing a pair of adjacent frequency channels corresponding to a respective pair of adjacent wavelength channels based upon a routing algorithm (e.g., see Figures 14 and 15; page 35, line 20, through page 36, line 30). The method may also comprise interchanging the frequencies of the selectively directed pair of adjacent frequency channels (e.g., see Figures 16 and 21; page 36, line 32, through page 38, line 12). The method may further comprise selectively shifting the interchanged frequencies of the selectively directed pair of adjacent frequency channels based upon a binary representation of each interchanged frequency (e.g., see Figures 17, 18, 19, 22, and 23; page 38, line 14, through page 44, line 15).

The claimed invention, as set forth in claim 2, and as described and shown in the specification and Figures 1-28 of the above-identified patent application, respectively, may be further defined by the step of selectively directing the pair of adjacent frequency channels comprising selectively switching the pair of adjacent frequency channels to one of two output pairs (e.g., see Figures 14 and 15; page 35, line 20, through page 36, line 30).

The claimed invention, as set forth in claim 3, and as

described and shown in the specification and Figures 1-28 of the above-identified patent application, respectively, may be further defined by the step of interchanging the frequencies of the selectively directed pair of adjacent frequency channels comprising routing the selectively directed pair of adjacent frequency channels based upon a binary representation of the frequency of each of the selectively directed pair of adjacent frequency channels (e.g., see Figures 16 and 21; page 36, line 32, through page 38, line 12).

The claimed invention, as set forth in claim 4, and as described and shown in the specification and Figures 1-28 of the above-identified patent application, respectively, may be further defined by the step of interchanging the frequencies of the selectively directed pair of adjacent frequency channels further comprising shifting the frequency of a first of the selectively directed pair of adjacent frequency channels by an amount defined by $+\Delta f$, and shifting the frequency of a second of the selectively directed pair of adjacent frequency channels by an amount defined by $-\Delta f$, wherein Δf is the frequency spacing between the pair of adjacent frequency channels (e.g., see Figures 16 and 21; page 36, line 32, through page 38, line 12).

The claimed invention, as set forth in claim 5, and as described and shown in the specification and Figures 1-28 of the

above-identified patent application, respectively, may be further defined by the step of selectively shifting the interchanged frequencies of the selectively directed pair of adjacent frequency channels comprising routing the selectively directed pair of adjacent frequency channels based upon the binary representation of each interchanged frequency (e.g., see Figures 17, 18, 19, 22, and 23; page 38, line 14, through page 44, line 15).

The claimed invention, as set forth in claim 9, and as described and shown in the specification and Figures 1-28 of the above-identified patent application, respectively, is directed to an apparatus for interchanging wavelengths in a multi-wavelength system having W wavelength channels (e.g., see Figures 12, 13, 20 and 24; page 34, line 20, through page 49, line 3). The apparatus may comprise a switching element for selectively directing a pair of adjacent frequency channels corresponding to a respective pair of adjacent wavelength channels based upon a routing algorithm (e.g., see Figures 14 and 15; page 35, line 20, through page 36, line 30). The apparatus may also comprise a state changer for interchanging the frequencies of the selectively directed pair of adjacent frequency channels (e.g., see Figures 16 and 21; page 36, line 32, through page 38, line 12). The apparatus may further

comprise a connection module for selectively shifting the interchanged frequencies of the selectively directed pair of adjacent frequency channels based upon a binary representation of each interchanged frequency (e.g., see Figures 17, 18, 19, 22, and 23; page 38, line 14, through page 44, line 15).

The claimed invention, as set forth in claim 10, and as described and shown in the specification and Figures 1-28 of the above-identified patent application, respectively, may be further defined by the switching element comprising a cross-connect for selectively switching the pair of adjacent frequency channels to one of two output pairs (e.g., see Figures 14 and 15; page 35, line 20, through page 36, line 30).

The claimed invention, as set forth in claim 11, and as described and shown in the specification and Figures 1-28 of the above-identified patent application, respectively, may be further defined by the state changer comprising a router for routing the selectively directed pair of adjacent frequency channels based upon a binary representation of the frequency of each of the selectively directed pair of adjacent frequency channels (e.g., see Figures 16 and 21; page 36, line 32, through page 38, line 12).

The claimed invention, as set forth in claim 12, and as described and shown in the specification and Figures 1-28 of the

above-identified patent application, respectively, may be further defined by the state changer further comprising a first frequency shifter for shifting the frequency of a first of the selectively directed pair of adjacent frequency channels by an amount defined by $+\Delta f$, and a second frequency shifter for shifting the frequency of a second of the selectively directed pair of adjacent frequency channels by an amount defined by $-\Delta f$, wherein Δf is the frequency spacing between the pair of adjacent frequency channels (e.g., see Figures 16 and 21; page 36, line 32, through page 38, line 12).

The claimed invention, as set forth in claim 13, and as described and shown in the specification and Figures 1-28 of the above-identified patent application, respectively, may be further defined by the connection module comprising a router for routing the selectively directed pair of adjacent frequency channels based upon the binary representation of each interchanged frequency (e.g., see Figures 17, 18, 19, 22, and 23; page 38, line 14, through page 44, line 15).

ISSUES ON APPEAL

Whether claims 1, 2, 9, and 10 are unpatentable over Doerr et al. (U.S. Patent No. 6,532,090) under 35 U.S.C. § 103(a).

Whether claims 3-5 and 11-13 are unpatentable over Doerr et al. (U.S. Patent No. 6,532,090) in view of Lee (U.S. Patent No. 5,148,428) under 35 U.S.C. § 103(a).

ARGUMENT

The Appellants respectfully appeal the decision of the Examiner to finally reject claims 1-5 and 9-13 of the present application. As discussed below, it is respectfully submitted that the Examiner has failed to establish a prima facie case of obviousness against the appealed claims.

I. THE EXAMINER HAS FAILED TO ESTABLISH A PRIMA FACIE CASE OF OBVIOUSNESS AGAINST CLAIMS 1, 2, 9, AND 10

As stated in MPEP § 2143, to establish a prima facie case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in applicant's disclosure. In re

Vaeck, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991). Also, as stated in MPEP § 2143.01, obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either in the references themselves or in the knowledge generally available to one of ordinary skill in the art. In re Fine, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988); In re Jones, 958 F.2d 347, 21 USPQ2d 1941 (Fed. Cir. 1992). The mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also suggests the desirability of the combination. In re Mills, 916 F.2d 680, 16 USPQ2d 1430 (Fed. Cir. 1990). Further, as stated in MPEP § 2143.03, to establish *prima facie* obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art. In re Royka, 490 F.2d 981, 180 USPQ 580 (CCPA 1974). That is, "[a]ll words in a claim must be considered in judging the patentability of that claim against the prior art." In re Wilson, 424 F.2d 1382, 165 USPQ 494, 496 (CCPA 1970). Additionally, as stated in MPEP § 2141.02, a prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention. W.L. Gore & Associates, Inc. v. Garlock, Inc., 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983),

cert. denied, 469 U.S. 851 (1984). Finally, if an independent claim is nonobvious under 35 U.S.C. 103, then any claim depending therefrom is nonobvious. In re Fine, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988).

Regarding claims 1 and 9, the Examiner asserts that Doerr et al. teaches a method for interchanging wavelengths in a multiwavelength system having W wavelength channels substantially as claimed. Specifically, the Examiner asserts that Doerr et al. teaches: selectively directing a pair of adjacent frequency channels corresponding to a respective pair of adjacent wavelength channels based upon a routing algorithm (reference numeral 910 in Figure 9); interchanging the frequencies of the selectively directed pair of adjacent frequency channels (reference numeral 930 in Figure 9); and selectively shifting the interchanged frequencies of the selectively directed pair of adjacent frequency channels (reference numeral 206 in Figure 2 and column 4 lines 24-32, column 6 lines 20-24). However, the Examiner acknowledges that Doerr et al. fails to teach shifting of interchanged frequencies based upon a binary representation of each interchanged frequency. But the Examiner then goes on to assert that frequency shifting of frequencies based upon a binary representation of the frequency is, as noted by the applicant

(page 13 lines 3-6), well known in the art and is accomplished via frequency mapping methods such as the butterfly permutation. The Examiner then goes on to further assert that frequency shift keying (FSK) is a well known digital method for assigning frequencies to specific binary representations. The Examiner then concludes that it would have been obvious to one skilled in the art at the time the invention was made to shift the interchanged frequencies based upon a binary representation of each interchanged frequency so as to arrive at the claimed invention.

First of all, Applicant respectfully submits that frequency shifting of frequencies based upon binary representations of the frequencies was not well known in the art at the time of the claimed invention. Applicant also respectfully objects to the Examiner's assertion that Applicant has acknowledged such. Specifically, the Examiner points to page 13, lines 3-6, of the present application to support the assertion that Applicant admits that frequency shifting of frequencies based upon binary representations of the frequencies is well known in the art. However, a clear contextual reading of this section of the present application will reveal that Applicant believes that connection patterns, such as shuffles or butterfly permutations, have interesting arithmetic properties that were not utilized or

even known before the realization of the present invention, and that the present invention exploits such properties so as to reduce converter costs. Accordingly, it is respectfully submitted that the present application does not support a teaching that frequency shifting of frequencies based upon binary representations of the frequencies was well known in the art at the time of the claimed invention.

Secondly, Applicant respectfully submits that Examiner's reliance on frequency shift keying (FSK) for a teaching of frequency shifting of frequencies based upon binary representations of the frequencies is misplaced. Specifically, as one with skill in the art understands, frequency shift keying (FSK) is a digital-to-analog modulation technique, wherein data is transmitted by shifting between two frequencies with ones represented by one frequency and zeros by the other. This is clearly inapplicable to the claimed invention as claims 1 and 9 both recite shifting frequencies based upon a binary representation of each interchanged frequency, and not upon a frequency representing binary ones or binary zeros. Accordingly, it is respectfully submitted that frequency shift keying (FSK) does not support a teaching of frequency shifting of frequencies based upon binary representations of the frequencies, as presently claimed.

With respect to the teachings of Doerr et al., it is respectfully submitted that, in contrast to the Examiner's assertions, Doerr et al. does not in fact teach selectively directing a pair of adjacent frequency channels corresponding to a respective pair of adjacent wavelength channels based upon a routing algorithm. Specifically, the Examiner points to the optical add-drop multiplexers (OADMs) 910 in Figure 9 of Doerr et al. for this teaching. However, the optical add-drop multiplexers (OADMs) 910 in Figure 9 of Doerr et al. are used to switch multiplexed signals having multiple optical wavelengths, not a pair of adjacent frequency channels corresponding to a respective pair of adjacent wavelength channels, as claimed. Furthermore, the OADMs 910 in Figure 9 of Doerr et al. are controlled by control signals, not by a routing algorithm, as claimed. Accordingly, it is respectfully submitted that Doerr et al. fails to teach, or even suggest, this claimed element.

Also, it is respectfully submitted that, in contrast to the Examiner's assertions, Doerr et al. does not in fact teach interchanging the frequencies of the selectively directed pair of adjacent frequency channels. Specifically, the Examiner points to the wavelength interchange (WI) 930 in Figure 9 for this teaching. However, the wavelength interchange (WI) 930 in Figure 9 of Doerr et al. is used to change the wavelength

assignments of all of the optical signals in a multiplexed signal having multiple optical wavelengths, not the frequencies of the selectively directed pair of adjacent frequency channels, as claimed. Accordingly, it is respectfully submitted that Doerr et al. fails to teach, or even suggest, this claimed element.

Furthermore, it is respectfully submitted that, in contrast to the Examiner's assertions, Doerr et al. does not in fact teach selectively shifting the interchanged frequencies of the selectively directed pair of adjacent frequency channels. Specifically, the Examiner points to the wavelength adapters (WA) 206 in Figure 2 for this teaching. However, the wavelength adapters (WA) 206 in Figure 2 of Doerr et al. are used to change the wavelength assignments of all of the optical signals in a multiplexed signal having multiple optical wavelengths, not selectively shift the interchanged frequencies of the selectively directed pair of adjacent frequency channels, as claimed. Accordingly, it is respectfully submitted that Doerr et al. fails to teach, or even suggest, this claimed element.

Accordingly, it is respectfully submitted that claims 1 and 9 of the present application are not unpatentable over Doerr et al., and thus the Examiner has failed in his duty to establish

at least a prima facie case of obviousness against claims 1 and 9 of the present application.

Regarding claim 2, the Examiner asserts that Doerr et al. teaches that the claimed step of selectively directing the pair of adjacent frequency channels comprises the step of selectively switching the pair of adjacent frequency channels to one of two output pairs. However, it is respectfully submitted that, in contrast to the Examiner's assertions, Doerr et al. does not in fact teach selectively switching the pair of adjacent frequency channels to one of two output pairs. Specifically, the Examiner points to the wavelength interchange (WI) 930 in Figure 9 for this teaching. However, the wavelength interchange (WI) 930 in Figure 9 of Doerr et al. are used to change the wavelength assignments of all of the optical signals in a multiplexed signal having multiple optical wavelengths, not selectively switch the pair of adjacent frequency channels to one of two output pairs, as claimed. Accordingly, it is respectfully submitted that Doerr et al. fails to teach, or even suggest, the elements recited in claim 2 of the present application.

Regarding claim 10, the Examiner asserts that Doerr et al. teaches that the claimed switching element comprises a cross-connect for selectively switching the pair of adjacent frequency channels to one of two output pairs. However, it is

respectfully submitted that, in contrast to the Examiner's assertions, Doerr et al. does not in fact teach that the claimed switching element comprises a cross-connect for selectively switching the pair of adjacent frequency channels to one of two output pairs. Specifically, the Examiner points to the wavelength selective optical cross-connect (WSC) 204 in Figure 2 for this teaching. However, the wavelength selective optical cross-connect (WSC) 204 in Figure 2 of Doerr et al. is used to route optical wavelength channels independently from any of k inputs to any of k outputs, not selectively switch the pair of adjacent frequency channels to one of two output pairs, as claimed. Accordingly, it is respectfully submitted that Doerr et al. fails to teach, or even suggest, the elements recited in claim 10 of the present application.

Furthermore, claims 2 and 10 are dependent upon independent claims 1 and 9, respectively. Thus, since independent claims 1 and 9 should be allowable as discussed above, claims 2 and 10 should also be allowable at least by virtue of their dependency on independent claims 1 and 9.

Accordingly, it is respectfully submitted that claims 2 and 10 of the present application are not unpatentable over Doerr et al., and thus the Examiner has failed in his duty to establish

at least a prima facie case of obviousness against claims 2 and 10 of the present application.

In view of the foregoing, it is respectfully requested that the obviousness rejection of claims 1, 2, 9, and 10 be withdrawn.

II. THE EXAMINER HAS FAILED TO ESTABLISH A PRIMA FACIE CASE OF OBVIOUSNESS AGAINST CLAIMS 3-5 AND 11-13

Regarding claims 3, 5, 11, and 13, the Examiner acknowledges that Doerr et al. fails to teach the elements recited in all of these claims, and then generally refers to Lee as a teaching of a switching element capable of performing a binary routing algorithm based on an n-bit destination address. However, these claims do not recite routing based upon an n-bit destination address, but rather recite routing a selectively directed pair of adjacent frequency channels based upon a binary representation of the frequency of each of the selectively directed pair of adjacent frequency channels, and routing a selectively directed pair of adjacent frequency channels based upon a binary representation of each interchanged frequency. Accordingly, it is respectfully submitted that the combination of Doerr et al. and Lee fail to teach, or even suggest, the elements recited in claims 3, 5, 11, and 13 of the present application.

Regarding claims 4 and 12, the Examiner acknowledges that both Doerr et al. and Lee fail to teach the elements recited in these claims, but then asserts that, since Doerr et al. teaches frequency shifting in general and that shifting by frequency spacing is well known in the art, it would have been obvious to one skilled in the art at the time the invention was made to arrive at the claimed invention. However, as discussed above, Doerr et al. does not teach shifting the frequency of a pair of adjacent frequency channels. Also, Applicant respectfully submits that there is no support in the record for the conclusion that the identified features are old and well known. In accordance with MPEP § 2144.03, the Examiner must cite a reference in support of his position. Accordingly, it is respectfully submitted that the combination of Doerr et al. and Lee fail to teach, or even suggest, the elements recited in claims 4 and 12 of the present application.

Furthermore, claims 3-5 and 11-13 are dependent upon independent claims 1 and 9. Thus, since independent claims 1 and 9 should be allowable as discussed above, claims 3-5 and 11-13 should also be allowable at least by virtue of their dependency on independent claims 1 and 9.

Accordingly, it is respectfully submitted that claims 3-5 and 11-13 of the present application are not unpatentable over

Doerr et al. in view of Lee, and thus the Examiner has failed in his duty to establish at least a prima facie case of obviousness against claims 3-5 and 11-13 of the present application.

In view of the foregoing, it is respectfully requested that the obviousness rejection of claims 3-5 and 11-13 be withdrawn.

CONCLUSION

In view of the foregoing, it is respectfully submitted that the Examiner has failed to establish a prima facie case of obviousness against the appealed claims. Thus, it is respectfully submitted that the final rejection of claims 1-5 and 9-13 under 35 U.S.C. § 103(a) is improper and the reversal of same is clearly in order and respectfully requested.

To the extent necessary, a petition for an extension of time under 37 C.F.R. § 1.136 is hereby made.

Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account 50-0206, and please credit any excess fees to such deposit account.

Patent Application
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Date: March 14, 2005

APPENDIX

1 (Original). A method for interchanging wavelengths in a multi-wavelength system having W wavelength channels, the method comprising the steps of:

selectively directing a pair of adjacent frequency channels corresponding to a respective pair of adjacent wavelength channels based upon a routing algorithm;

interchanging the frequencies of the selectively directed pair of adjacent frequency channels; and

selectively shifting the interchanged frequencies of the selectively directed pair of adjacent frequency channels based upon a binary representation of each interchanged frequency.

2 (Original). The method as defined in claim 1, wherein the step of selectively directing the pair of adjacent frequency channels comprises the step of:

selectively switching the pair of adjacent frequency channels to one of two output pairs.

3 (Original). The method as defined in claim 1, wherein the step of interchanging the frequencies of the selectively directed pair of adjacent frequency channels comprises the step of:

routing the selectively directed pair of adjacent frequency channels based upon a binary representation of the frequency of each of the selectively directed pair of adjacent frequency channels.

4 (Original). The method as defined in claim 3, wherein the step of interchanging the frequencies of the selectively directed pair of adjacent frequency channels further comprises the steps of:

shifting the frequency of a first of the selectively directed pair of adjacent frequency channels by an amount defined by $+\Delta f$; and

shifting the frequency of a second of the selectively directed pair of adjacent frequency channels by an amount defined by $-\Delta f$;

wherein Δf is the frequency spacing between the pair of adjacent frequency channels.

5 (Original). The method as defined in claim 1, wherein the step of selectively shifting the interchanged frequencies of the selectively directed pair of adjacent frequency channels comprises the step of:

routing the selectively directed pair of adjacent frequency

channels based upon the binary representation of each interchanged frequency.

6 (Original). The method as defined in claim 5, wherein the step of selectively shifting the interchanged frequencies of the selectively directed pair of adjacent frequency channels further comprises the step of:

shifting the frequency of at least one of the selectively directed pair of adjacent frequency channels by an amount defined by $\pm(2^h-1)\Delta f$, wherein $h=0,\dots,w-1$, $w=\log_2 W$, and Δf is the frequency spacing between the pair of adjacent frequency channels.

7 (Original). The method as defined in claim 5, wherein the step of selectively shifting the interchanged frequencies of the selectively directed pair of adjacent frequency channels further comprises the steps of:

shifting the frequency of at least one of the selectively directed pair of adjacent frequency channels by an amount defined by $-2^h\Delta f$;

increasing the shifted frequency of the at least one of the selectively directed pair of adjacent frequency channels; and

shifting the increased shifted frequency of the at least

one of the selectively directed pair of adjacent frequency channels by an amount defined by $+\Delta f$;

wherein $h=0,\dots,w-1$, $w=\log_2 W$, and Δf is the frequency spacing between the pair of adjacent frequency channels.

8 (Original). The method as defined in claim 5, wherein the step of selectively shifting the interchanged frequencies of the selectively directed pair of adjacent frequency channels further comprises the steps of:

shifting the frequency of at least one of the selectively directed pair of adjacent frequency channels by an amount defined by $-\Delta f$;

decreasing the shifted frequency of the at least one of the selectively directed pair of adjacent frequency channels; and

shifting the decreased shifted frequency of the at least one of the selectively directed pair of adjacent frequency channels by an amount defined by $+2^h \Delta f$;

wherein $h=0,\dots,w-1$, $w=\log_2 W$, and Δf is the frequency spacing between the pair of adjacent frequency channels.

9 (Original). An apparatus for interchanging wavelengths in a multi-wavelength system having W wavelength channels, the

apparatus comprising:

a switching element for selectively directing a pair of adjacent frequency channels corresponding to a respective pair of adjacent wavelength channels based upon a routing algorithm;

a state changer for interchanging the frequencies of the selectively directed pair of adjacent frequency channels; and

a connection module for selectively shifting the interchanged frequencies of the selectively directed pair of adjacent frequency channels based upon a binary representation of each interchanged frequency.

10 (Original). The apparatus as defined in claim 9, the switching element comprises:

a cross-connect for selectively switching the pair of adjacent frequency channels to one of two output pairs.

11 (Original). The apparatus as defined in claim 9, wherein the state changer comprises:

a router for routing the selectively directed pair of adjacent frequency channels based upon a binary representation of the frequency of each of the selectively directed pair of adjacent frequency channels.

12 (Original). The apparatus as defined in claim 11, wherein the state changer further comprises:

a first frequency shifter for shifting the frequency of a first of the selectively directed pair of adjacent frequency channels by an amount defined by $+\Delta f$; and

a second frequency shifter for shifting the frequency of a second of the selectively directed pair of adjacent frequency channels by an amount defined by $-\Delta f$;

wherein Δf is the frequency spacing between the pair of adjacent frequency channels.

13 (Original). The apparatus as defined in claim 9, wherein the connection module comprises:

a router for routing the selectively directed pair of adjacent frequency channels based upon the binary representation of each interchanged frequency.

14 (Original). The apparatus as defined in claim 13, wherein the connection module further comprises:

at least one frequency shifter for shifting the frequency of at least one of the selectively directed pair of adjacent frequency channels by an amount defined by $\pm(2^h-1)\Delta f$, wherein $h=0,\dots,w-1$, $w=\log_2 W$, and Δf is the frequency spacing between the

pair of adjacent frequency channels.

15 (Original). The apparatus as defined in claim 13, wherein the connection module further comprises:

a first frequency shifter for shifting the frequency of at least one of the selectively directed pair of adjacent frequency channels by an amount defined by $-2^h \Delta f$;

an increasing up-converter for increasing the shifted frequency of the at least one of the selectively directed pair of adjacent frequency channels; and

a second frequency shifter for shifting the increased shifted frequency of the at least one of the selectively directed pair of adjacent frequency channels by an amount defined by $+\Delta f$;

wherein $h=0, \dots, w-1$, $w=\log_2 W$, and Δf is the frequency spacing between the pair of adjacent frequency channels.

16 (Original). The apparatus as defined in claim 13, wherein the connection module further comprises:

a first frequency shifter for shifting the frequency of at least one of the selectively directed pair of adjacent frequency channels by an amount defined by $-\Delta f$;

an increasing down-converter for decreasing the shifted

frequency of the at least one of the selectively directed pair of adjacent frequency channels; and

a second frequency shifter for shifting the decreased shifted frequency of the at least one of the selectively directed pair of adjacent frequency channels by an amount defined by $+2^h\Delta f$;

wherein $h=0,\dots,w-1$, $w=\log_2 W$, and Δf is the frequency spacing between the pair of adjacent frequency channels.